1,063,020

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,063,020

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Int. Cl.:—F 05 b

COMPLETE SPECIFICATION

Reciprocating Pump for Semi-liquid Materials

I, EUGENE LEE SHERROD, of 105 Leanore Lane, Brookfield, Wisconsin, United States of America, a citizen of the United States of America, do hereby declare the invention for which I pray that a patent may be granted to me and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to positive displacement pumps and has more particular reference to improvements in valve mechanism for pumps of the type which are designed to handle materials or products that are semi-liquid in nature and have poor flow characteristics, such as freshly mixed concrete.

All such pumps, of course, require valve means to control communication of the pumping cylinders with both a feed chamber and a delivery line; and it will also be appreciated that valve and piston movements have to be syncronized to ensure communication between the feed chamber and each cylinder on the charging stroke of its piston, and similarly to assure communication between the delivery line and each cylinder on the discharging stroke of its piston.

The valve mechanisms ordinarily provided for semi-liquid pumps in the past, and especially for concrete pumps, left much to be desired. They were objectionable for many reasons but primarily because of the multiplicity of valves employed therein. In the simpler pumps, one valve was provided for each pumping cylinder; while in more complicated pumps, it was not unusual to provide separate charging and discharge valves for each pumping cylinder. Moreover, the valve mechanism employed in the past were often quite complicated and not always reliable in operation.

In addition, it was also very difficult to provide the valve mechanisms heretofore in use with the necessary pressure seals, without involving the use of two or more seals per valve. Frequently, these seals had to be applied to objectionably large diameter surfaces of the valves, due to their peculiar natures.

With these objections in mind, it is a primary purpose of this invention to provide a semi-liquid pump with valve mechanism which overcomes the disadvantages noted, and which is relatively simple in construction and efficient in operation.

According to the invention there is provided a positive displacement pump comprising at least one pump cylinder open at one end to provide for induction of material to be pumped into the cylinder during the retraction stroke of a piston in the cylinder and to provide for discharge of the material from the cylinder during the extension stroke of the piston, drive means operable to drive the piston back and forth in the cylinder, a feed chamber fixed relative to the pump cylinder and having spaced apart upright front and rear walls connected by bottom and side walls, an inlet which opens into its upper portion to admit to the feed chamber material to be pumped, a cylinder port opening through said rear wall and communicating with the open end of the pump cylinder, a valve member mounted in the feed chamber for rotary motion about an axis fixed with respect thereto and normal to said front and rear walls thereof, said valve member extending substantially entirely across the space between the front and rear walls and having a rear portion operable upon rotary movement of the valve member from one operating position to another to cover and close off the cylinder port from the interior of the feed chamber, passage means extending fore and aft through the valve member having an inlet end to communicate with the cylinder port when covered by said rear portion of the valve member, and means at the front of the feed chamber providing a delivery port at all times connected with the outlet end of said passage

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means in the valve member, said delivery port being closed off from the interior of the feed chamber by the front end portion of the valve member, and the underside of the valve member being concentric with the rotational axis of the valve member and mating with a curved surface on the bottom portion of the chamber.

The pump preferably comprises at least two pump cylinders, said rear wall being provided with two cylinder ports each communicating with the open end of a separate one of the two cylinders, and the rear portion of the valve member being arranged to cover and close off first one and then the other of the cylinder ports from the interior of the feed chamber upon rotary movement of the valve member from one operating position to the other, the inlet end of said passage means communicating with whichever one of said cylinder ports is covered by said rear portion of the valve member.

The improved pump is particularly suitable for use with concrete, since stone or other solids in the concrete cannot accumulate between the bottom surface of the feed chamber and the underside of the valve member, or for concrete to "build up" i.e. accumulate and set, on any surface of the feed chamber or valve member and thereby interfere with free motion of the valve member.

The accompanying drawings illustrate two complete examples of the physical embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a plan view of a three cylinder semi-liquid pump embodying valve mechanism of this invention;

Figure 2 is a sectional view taken through Figure 1 along the line 2—2, parts thereof being shown in elevation;

Figure 3 is a cross sectional view taken through Figure 2 along the plane of line 3—3;

Figure 4 is a view partially in elevation and partially in section illustrating another three cylinder semi-liquid pump embodying valve mechanism of this invention;

Figure 5 is a cross section view taken through Figure 4 on the plane of line 5—5;

Figure 6 is another cross sectional view taken through Figure 4 on the plane of line 6—6;

Figure 7 is a view similar to Figure 6 showing the parts in another position of operation; and

Figure 8 is a cross sectional view taken through Figure 4 on the plane of line 8—8, more or less diagrammatically showing the manner in which the valve element governs the three cylinder ports of the pump.

Referring now more particularly to the accompanying drawings, in which like reference characters have been applied to like parts throughout the views, the numeral 10 in Figure 1 generally designates the feed chamber of a semi-liquid pump comprising three pumping cylinders 11, 12 and 13. The cylinders are arranged to receive the material or product to be pumped from the interior of the feed chamber under the control of valve mechanism 14 of this invention, which valve mechanism is mounted in the feed chamber and also serves to conduct material discharged from the pumping cylinders to a delivery line 15 common to the cylinders.

As is customary, the piston 16 in each pumping cylinder is reciprocated by power means which, in the present case, is illustrated as comprising hydraulic cylinders 17, one for each pumping cylinder, having a piston rod 18 connected with the piston 16 of the pumping cylinder in the manner illustrated best in Figure 2. These operating or driving cylinders 17 are all of the double acting variety, and their operation may be timed and synchronized with that of the valve mechanism in the manner disclosed in my co-pending British Patent Application No. 28051/62 (Serial No. 1,004,845).

The feed chamber 10 comprises a receptacle having an open top providing an inlet 20, opposite flat upright walls 21 and 22 at the front and rear of the receptacle, respectively, and a bottom wall generally designated 23, having a substantially flat centre section 24 and upwardly and outwardly convergent end sections 25 joined to the bottom section by outwardly convex or rounded bottom wall sections 26.

As shown, the rear wall 22 of the feed chamber may be substantially reinforced by a heavy plate 27 to which the forward ends of the pumping cylinders 11, 12 and 13 are secured; and holes 11′, 12′ and 13′ in the rear wall and the plate 27 provide cylinder ports that register with the open front ends of the cylinders 11, 12 and 13, respectively.

Primarily to illustrate the versatility of the valve mechanism 14 of this invention, it has here been shown as compprised of two valve members 29 and 30, each mounted in the feed chamber and extending across the space between its front and back walls 21 and 22. As will be described at greater length hereinafter, the valve member 29 serves two of the pumping cylinders 11 and 12, while the third pumping cylinder is served by the valve member 30.

Each of the valve members has a delivery passage 31 extending fore and aft therethrough which passage has a shallow S-shaped bend in it The forward or outlet ends of the delivery passages 31 of the valve members register with delivery ports 32 in the front wall 21 of the feed chamber located substantially on the axes of curvature of

the two rounded bottom wall sections 26 of the feed chamber. A Y-shaped duct 34, sometimes referred to as a "Siamese" pipe, has a stem 35 that joins with the delivery line 15 and opposite branches 35' which extend rearwardly from its stem and are connected with the front wall of the feed chamber by flanged couplings 36, in register with the delivery ports 32.

Each of the valve members 29 and 30 is mounted in the feed chamber and supported for rotation about the axis of its delivery port 32, with the outlet end of its delivery passage 31 coaxial with the delivery port and at all times in register therewith.

In the pump shown, each of the valve members has a slightly reduced cylindrical forward end portion that projects through its delivery port 32 and is journalled in a bearing sleeve 37 located partly in the delivery port and partly in the adjacent coupling 36. This sleeve also provides a pressure seal that extends forwardly past the end of its valve member and into the coupling 36 to prevent leakage of material being pumped from the joint between the valve member and its coupling. A trunion 38 on the rear end portion of each valve member, coaxial with its bearing 37, is received in a bearing 39 in the rear wall and the plate 27 of the chamber, as best seen in Figure 2. The front and rear bearings 37 and 39 for the valve members thus co-operates to support the valve members for rotary motion about fixed parallel axes that have been shown as lying in a common horizontal plane.

As also seen in Figure 2, the outlet end of the delivery passage 31 in each of the valve members is coaxial with both the front and rear bearings for the valve member, but the rear or inlet end of the delivery passage 31 is offset radially a distance from the axis of rotation of the valve member due to the curved shape of the passage. Hence, the inlet end of the discharge passage in each valve member travels in an orbit that is concentric to the axis about which the valve member rotates.

The rear portion 40 of each valve member is engaged flat against the inner surface of the rear wall 22 of the feed chamber, and it is widened along its orbit of travel, as seen best in Figure 3. It is also shaped to have an outer surface that is concentric to the axis about which the valve member rotates, and which is contiguous to the curved corner sections 26 of the feed chamber. The delivery passage 31 in each valve member is also progressively widened, in the direction of orbital travel of its rear portion, toward the mouth 31' of the delivery passage.

Each valve member is oscillatable back and forth through an arc of about 65°, between a first operating position at which its wider rear end portion is below the valve axis, or adjacent to the flat bottom wall portion 24 of the feed chamber, and a second operating position at which said wider rear portion of the valve member is disposed laterally alongside the valve axis, between the latter and the adjacent upwardly convergent end wall 25 of the feed chamber. The cylinder ports 11' and 13' are located nearly directly beneath the axes of the valve elements 29 and 30, respectively, to be covered by the wider rear portions of the valve members when both are in their first operating positions described, and at which positions the wide mouths of the valve members are in register with the cylinder ports 11' and 13'.

Figure 3 shows the valve member 29 in its first operating position, and valve member 30 in its second operating position.

Hence, the valve member 29 is in a delivery position with respect to the cylinder port 11', at which it conducts material discharging from cylinder 11 through the delivery port 32 to the delivery line 15. The valve member 30, however, is in a charging position with respect to its cylinder port 13', permitting direct communication of cylinder 13 with the interior of the feed chamber.

In this position of the valve member 29, its wider rear portion lies entirely below the cylinder port 12', which is located laterally of the axis of valve member 29, between said axis and the adjacent upwardly convergent end wall 25 of the feed chamber. Accordingly, whenever the valve member is in a delivery position with respect to the cylinder port 11', as shown in Figure 3, it is in a charging position with respect to its other cylinder port 12'. Conversely, when the valve member is swung clockwise as viewed in Figure 3 to its second operating position, corresponding to the position of valve member 30 and covering the cylinder port 12', it is then in a delivery position with respect to cylinder 12 and a charging position with respect to cylinder 11.

With the arrangement described, of course, the cylinder ports are offset from the axes of rotation of their respective valve members a distance equal to the radial offset between the inlet and outlet ends of the curved delivery passages in the valve members. If desired, the cylinder ports may be widened or flared at diametrically opposite sides, in the direction of orbital travel of the valve members, and forwardly toward the feed chamber, so as to more or less match the shape of the inlet ends of the delivery passages in the valve members.

In operation, when the valve member 30 is in its charging position seen in Figure 3, the product to be pumped is inducted into the cylinder 13 from the interior of the feed chamber during the charging stroke of the piston 16 in said cylinder, inasmuch as the cylinder port 13' is then in direct communi-

cation with the interior of the feed chamber. At the completion of the charging stroke of the piston, the valve member 30 is rotated in the clockwise direction as seen in Figure 3, to bring the mouth of its delivery passage into register with the cylinder port 13′ to close it off from the interior of the feed chamber and to then communicate it with the delivery port 32 in the forward wall of the feed chamber. Thereafter the piston 16 in the pumping cylinder 13 can begin its discharge stroke during which it travels forwardly in its cylinder to expel material forwardly through the cylinder port 13′ and the delivery passage 31 to the delivery line 15.

Power means is provided to oscillate the valve member 30 between its charging and discharging positions described. As shown, such power means may comprise a double acting fluid pressure cylinder 42 carried by a bracket 43 mounted on the end wall of the feed chamber remote from the valve member 30, and having the cylinder pivotally connected thereto as at 44 for rocking motion about a fore and aft extending horizontal axis. The piston rod 45 of the cylinder has its forward end connected by a pin 46 with an upstanding arm 47 joined to the top portion of the valve member 30 so that extension of the piston rod from its position seen in Figure 3 rocks the valve member from its charging position shown to its discharging position covering the cylinder port 13′.

Subsequent retraction of the piston rod returns the valve member 30 to its charging position shown.

The valve mechanism described lies entirely to one side of the cylinder port 13′ when in its charging position, so that the product to be pumped can flow freely from the interior of the feed chamber for induction into the pumping cylinder 13 on the charging stroke of its piston. Also in this charging position, the rear wall 22 of the feed chamber closes the mouth of the delivery passage 31 in the valve member, to prevent back flow of material into the feed chamber from the delivery line 15. In the discharging or delivery position of the valve member 30, its curved passage 31 smoothly conducts the material expelled from the cylinder 13 on the discharge stroke of its piston, to the delivery port and ultimately the delivery line 15, with a minimum of resistance to flow due to the gentle curvature of the delivery passage 31.

The other valve member 29 is similar to the valve member 30, and as seen in Figure 3 is arranged symmetrically therewith about a median vertical plane of the feed chamber normal to its flat front and rear walls 21 and 22, respectively. The valve member 29, however, serves two pumping cylinders, namely the cylinders 11 and 12. In each of its operating positions, it is in discharging relation with respect to one of its cylinder ports and at the same time in charging relation with respect to its other cylinder port.

During operation of the pump, the valve member 29, in its position seen in Figure 3, conducts material discharging from the pumping cylinder 11 to the delivery line while at the same time allowing material from the feed chamber to be inducted into the pumping cylinder 12 through its cylinder port 12′. For this purpose, of course, the pistons in the two cylinders 11 and 12 can be operated such that they move in opposite directions.

A second fluid pressure operated cylinder 52 is provided to impart oscillatory motion to the valve member 29 between its two operating positions described. Its piston rod 53 is connected with an upstanding arm 54 on the valve member 29 corresponding to the arm 47 of the valve member 30. In this case, however, the cylinder 52 is mounted on a bracket 55 carried by the opposite end wall of the feed chamber, for up and down rocking motion about the axis of a pin 56 in the bracket.

Figure 3 shows the piston rod 53 of cylinder 52 extended, with the valve member 30 at its limit counterclockwise motion. When the piston rod 53 is retracted, it imparts clockwise rocking motion to the valve member to carry it through an angle of approximately 55° to its second operating position covering the cylinder port 12′ and uncovering the cylinder port 11′

It will be apparent, of course, that the operation of the pumping cylinders and the valve operating cylinders can be so synchronized that as soon as each pumping cylinder is fully charged, the valve member for that cylinder will be moved to a delivery position with respect to the charged cylinder, ready to conduct to the delivery line material expelled from the cylinder by forward travel of its piston.

If desired, the pistons in the pumping cylinders 11, 12 and 13 can be driven with the differential rates disclosed in my copending Application No. 28051/62 (Serial No. 1,004,845) namely with each piston driven at the same optimum charging speed and at a discharging speed which is twice that of charging; and with two pistons moving rearwardly at the same time through different fractions of their charging strokes while the third piston is driven forwardly at higher speed in its discharge stroke.

From the description thus far it will be readily apparent that a fourth pumping cylinder could very well be incorporated in the apparatus shown in Figures 1 to 3 to be served by the valve member 30 in the same way as the pumping cylinder 12 is served by the valve member 29. The cylinder port (not shown) of the fourth cylinder would, of

course, open through the rear wall of the feed chamber in symmetrical relationship to the cylinder port 12'.

Thus, the same valve member may be employed in either a single or a double cylinder pump, and a pair of right and left valve members 29 and 30 may be employed in either a two cylinder, a three cylinder or a four cylinder pump.

Figures 4 to 8 disclose a modified form of pumping apparatus in which a single valve member 60, like that previously described, is operable to serve three pumping cylinders. The valve member 60 is in this case also mounted within a feed chamber 65 having flat upright front and rear walls 66 and 67, respectively, a semi-circular bottom wall 68 which is concentric to the axis of a delivery port 69 in the front wall 66, and more or less upright end walls 70, the lower portions of which converge toward their junctions with the curved bottom wall 68.

The valve member 60 has a cylindrical front end portion, a rear portion which is engaged flat against a port adaptor or wear plate 72 that is secured to the rear wall 67 at the inside of the feed chamber, and a part-cylindrical bottom surface which extends the full axial length of the valve member and is a continuation of the cylindrical surface at the front of the valve member, the part-cylindrical bottom surface being concentric with the rotational axis of the valve member and mating with the inner surface of the curved bottom wall 68.

A cylinder block 73 which is bored to provide three pumping cylinders is fastened to the rear wall 67 of the feed chamber, and the front end portions of the cylinders register with cylinder ports 74, 75 and 76 in the wear plate and rear wall of the feed chamber. These cylinder ports are arranged in angularly equispaced relationship about the axis of the delivery port 69 and spaced equal radial distances therefrom.

The inlet of the feed chamber is here shown communicated with the forward end portion of a conveyor trough, generally designated 77, in which a screw or the like, not shown, may be provided to propel the product to be pumped forwardly into the feed chamber.

The valve member 60 has what may be termed a cylindrical hub portion 78 that is freely rotatably received in the delivery port 69, and a reduced tubular portion 78' that projects forwardly through a pair of outboard bearings 79 and 80 to co-operate therewith in mounting the valve member coaxially of the delivery port 69. The bearing 79 is secured to the outer side of the front wall 66 of the feed chamber, while the bearing 80 is carried by a bearing supporting member or pedestal 81. The pedestal is bored to receive the forward end 82 of the tubular portion 78' and to also receive a tubular rear portion 83 on a coupling 84 that is secured to the front of the pedestal and provides for attachment of a delivery line (not shown) to the pumping apparatus.

The pedestal 81, in addition to providing a forward bearing for the valve member, also contains the single high pressure seal, generally designated 85, that is needed to seal the joint between the forward end of the valve member and the delivery line coupling 84.

The valve member 60 also has a delivery passage 87 extending fore and aft therethrough, with its forward end portion gently merging into the tubular forward extension of the valve member. Its inlet or rear end portion is the same diameter as the forward end portion and opens through the rear part of the valve member that sweeps across the inner surface of the wear and port adaptor plate 72. This delivery passage 87 is similarly curved so that its inlet end is radially offset from the axis of rotation of the valve a distance corresponding to the radial distances between said axis and the cylinder ports 74, 75 and 76.

Hence, in each of three angular positions equispaced from one another and at which the inlet end of the delivery passage 87 registers with a different one of the cylinder ports, the material in the pumping cylinder associated with said port may be discharged forwardly through the delivery passage 87 in the valve member and out through the tubular forward extension 78' to the delivery line. During such discharge of each pumping cylinder, the two remaining cylinders can be charging, and for this purpose, the rear end portion of the valve member is made large enough to cover only one cylinder port at a time. As shown in dotted lines 88 in Figure 8, the rear end portion of the valve member is of sector shaped cross-section and has side surfaces joining its part-cylindrical bottom surface and forming therewith abrupt edges which sweep across the curved surface of the bottom of the feed chamber to plough all but the smallest sized materials in the feed chamber off the surface of the bottom wall about to be covered by the valve member as the valve member moves from one operating position to another.

This diagram also shows the arrangement of cylinder ports 74, 75 and 76 in the wear or port adaptor plate 72, looking at the latter from inside the feed chamber. As therein seen, the cylinder ports are round, and the rear end portion 88 of the valve member is of a size to cover the port 74 when the valve member is in its discharging position communicating the associated cylinder with the delivery line. In that position, the valve member leaves the other two ports 75 and 76

open and in direct charging communication with the interior of the feed chamber.

When the valve member is rotated about its axis through an angle of 120° in the clockwise direction, as viewed in Figure 8, it covers the cylinder port 75 to communicate its associated cylinder with the delivery line and leaves the cylinder ports 74 and 76 uncovered and in direct communication with the interior of the feed chamber so that the latter may be charged while the cylinder associated with the port 75 discharges.

Similarly, rotation of the valve member through another 120° of rotation in the clockwise direction brings it to its third operating position covering the port 76 to enable the cylinder associated therewith to be discharged to the delivery line while the ports 74 and 75 are uncovered and in direct charging communication with the interior of the feed chamber, so that the cylinders associated with the ports 74 and 75 may be charged while the cylinder associated with the port 76 is discharging.

The valve member 60 is adapted to be intermittently driven in one direction about its axis of rotation, to each of its operating positions. A ratchet 90, fixed to the exterior of the tubular forward extension 78' of the valve member, at a location between the two outboard bearings 79 and 80, is provided for that purpose. The ratchet has three lobes 91, 92 and 93 which are adapted to be acted upon by a pair of actuators 94 and 95 to effect the desired intermittent advance of the valve member. These actuators comprise the piston rods of fluid pressure cylinders 96 and 97, each of which carries a roller 98 on its outer end for engagement with radially disposed working faces 99 on the ratchet lobes to effect clockwise rotation thereof, as viewed in Figures 6 and 7, in consequence of extension of the piston rods 94 and 95.

The cylinders 96 and 97 are operated in opposite phase relationship, so that with the parts in their positions seen in Figure 6, extension of the piston rod 94 by its cylinder can taken place simultaneously with retraction of the piston rod 95. When that occurs, the roller 98 on the piston rod 94 pushes against the working face of the lobe 91 to rotate the ratchet and the valve member clockwise through an angle of 60°, while the lobe 92 is carried down to a position ahead of the roller on the now retracted piston rod 95 of the cylinder 97. Figure 7 shows the positions of the ratchet and piston rods after such actuation of the ratchet. The piston rod 94 may now be retracted while the piston rod 95 is extended so that the roller on rod 95 pushes against the working face of lobe 92 to cause the ratchet to be rotated another 60° in the clockwise direction, and thus complete the movement of the valve member through the 120° increment necessary to shift it from one operating position to the next.

The two cylinders 96 and 97 are mounted at opposite sides of the forwardly extending tubular part of the valve member, both cylinders being mounted on pivotal supports 100 at their outer ends, so that they can rock up and down as the rollers on their piston rods ride over the lobes to operating positions confronting the working faces of the lobes.

As indicated in Figure 7, the cylinder 96 is yieldingly biased in a downward direction by a tension spring 101, while the cylinder 94 is yieldingly urged upwardly by an expansion spring 102.

It will be noted that with the pumping apparatus disclosed in Figures 4 to 8, the valve member is rotated in only one direction to its successive operating positions, by mechanism that is located entirely outside the feed chamber.

From the foregoing description, together with the accompanying drawings, it will be apparent, to those skilled in the art that this invention provides a semi-liquid pump having valve mechanism that is exceptionally simple in design, highly efficient in operation, and which further readily lends itself to use in pumps having one, two or a plurality of pumping cylinders.

WHAT I CLAIM IS:—

1. A positive displacement pump comprising at least one pump cylinder open at one end to provide for induction of material to be pumped into the cylinder during the retraction stroke of a piston in the cylinder and to provide for discharge of the material from the cylinder during the extension stroke of the piston, drive means operable to drive the piston back and forth in the cylinder, a feed chamber fixed relative to the pump cylinder and having spaced apart upright front and rear walls connected by bottom and side walls, an inlet which opens into its upper portion to admit to the feed chamber material to be pumped, a cylinder port opening through said rear wall and communicating with the open end of the pump cylinder, a valve member mounted in the feed chamber for rotary motion about an axis fixed with respect thereto and normal to said front and rear walls thereof, said valve member extending substantially entirely across the space between the front and rear walls and having a rear portion operable upon rotary movement of the valve member from one operating position to another to cover and close off the cylinder port from the interior of the feed chamber, passage means extending fore and aft through the valve member having an inlet end to communicate with the cylinder port when covered by said rear portion of the valve member, and means at the front of the feed chamber providing a delivery port at all times connected with the outlet end of said passage means in the valve

member, said delivery port being closed off from the interior of the feed chamber by the front end portion of the valve member, and the underside of the valve member being concentric with the rotational axis of the valve member and mating with a curved surface on the bottom portion of the chamber.

2. A positive displacement pump as claimed in claim 1 and comprising at least two pump cylinders, wherein said rear wall is provided with two cylinder ports each communicating with the open end of a separate one of the two cylinders, and the rear portion of the valve member is arranged to cover and close off first one and then the other of the cylinder ports from the interior of the feed chamber upon rotary movement of the valve member from one operating position to the other, the inlet end of said passage means communicating with whichever one of said cylinder ports is covered by said rear portion of the valve member.

3. A positive displacement pump as claimed in claim 1 or 2, further characterized by side surfaces on the valve member joining its bottom surface and forming therewith abrupt edges which sweep across the curved surface of the bottom of the feed chamber to plough all but the smallest sized material in the feed chamber off the surface of the bottom wall about to be covered by the valve member as the valve member moves from one operating position to another.

4. A positive displacement pump as claimed in claim 1 or 2, further characterized by the fact that the mating curved surfaces on the valve member and the bottom portion of the chamber extend for the full axial length of the valve member.

5. A positive displacement pump as claimed in claim 4, further characterized by the fact that said mating curved surfaces are uniformly spaced from the rotational axis of the valve member.

6. A positive displacement pump as claimed in claim 5, further characterized by the fact that the front end portion of the valve member is cylindrical and the curved surface on the underside of the valve member is a continuation of the cylindrical surface at the front end portion thereof.

7. A positive displacement pump as claimed in claim 6, further characterized by the fact that the rear end portion of the valve member has a sector-shaped cross section.

8. A positive displacement pump as claimed in claim 1 and comprising three pump cylinders, wherein the feed chamber has at least three cylinder ports equi-spaced from one another and from the axis about which the valve member turns; wherein the rear end portion of the valve member is of a size and shape to cover one of the cylinder ports while leaving two other cylinder ports in open communication with the interior of the feed chamber in each operating position of the valve member, and further characterized by power means operatively connected with the valve member to impart torque to the same to turn the valve member from one operating position to another.

9. A positive displacement pump as claimed in claim 8, wherein a total of three cylinder ports open to the feed chamber, and wherein the power means imparts only unidirectional torque to the valve member, so that the valve member always turns in the same direction as it moves from one operating position to another.

10. A positive displacement pump substantially as hereinbefore described with reference to Figures 1—3 or Figures 4—8 of the accompanying drawings.

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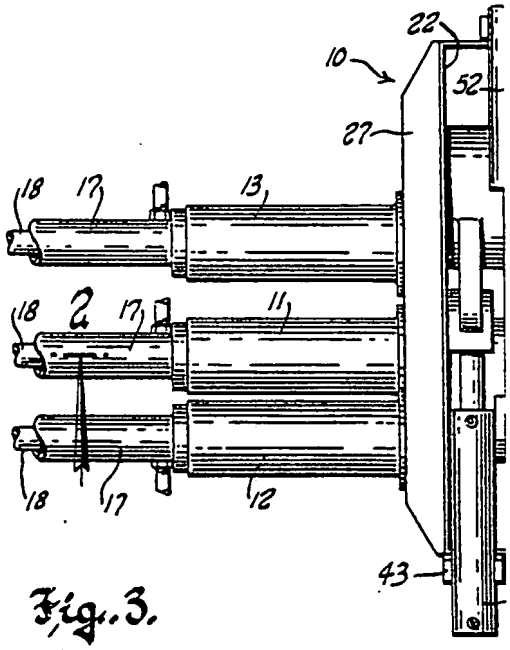
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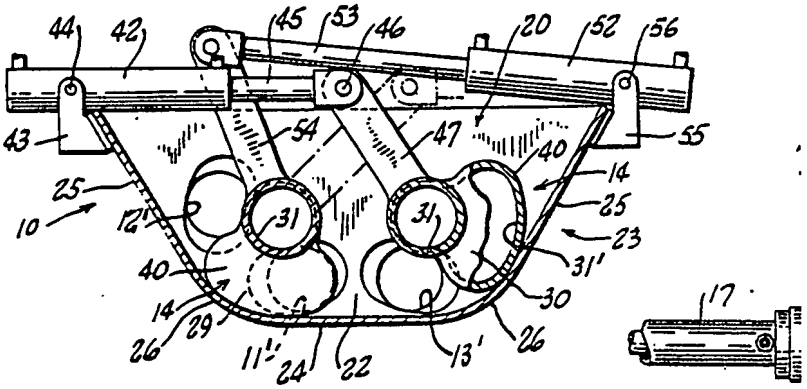
Fig. 3.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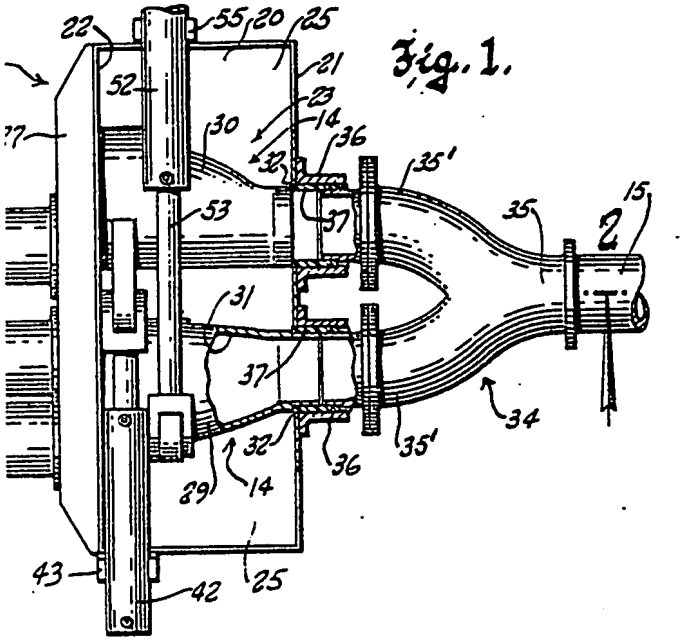

Fig. 1.

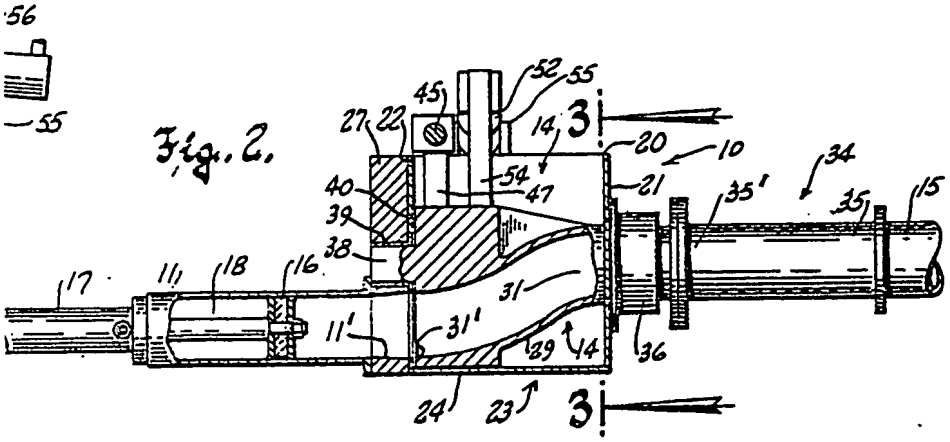

Fig. 2.

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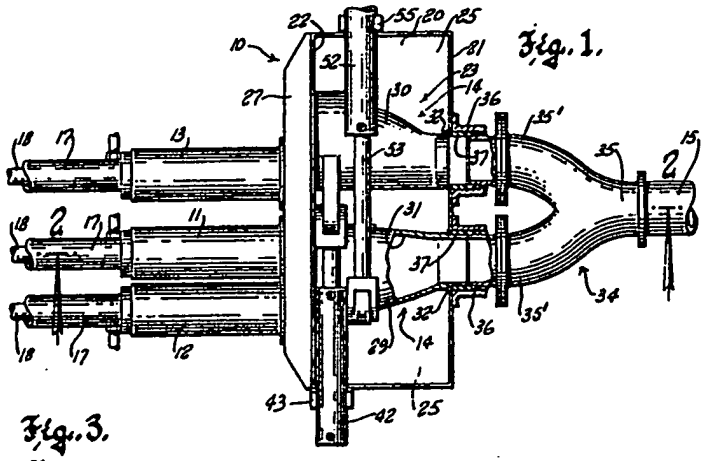


Fig. 1.

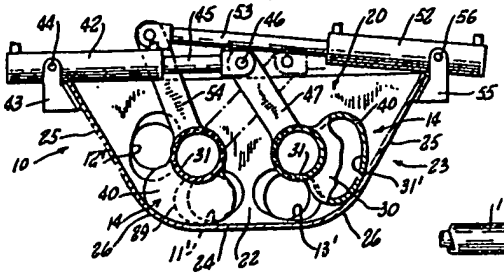


Fig. 3.

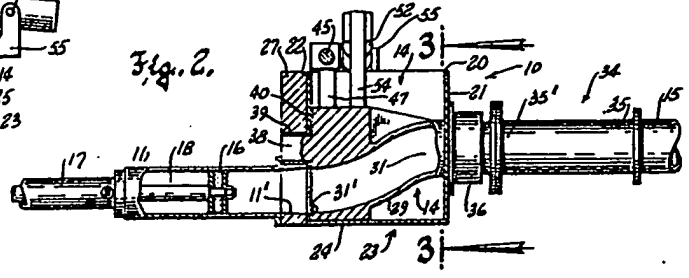


Fig. 2.

Fig. 4.

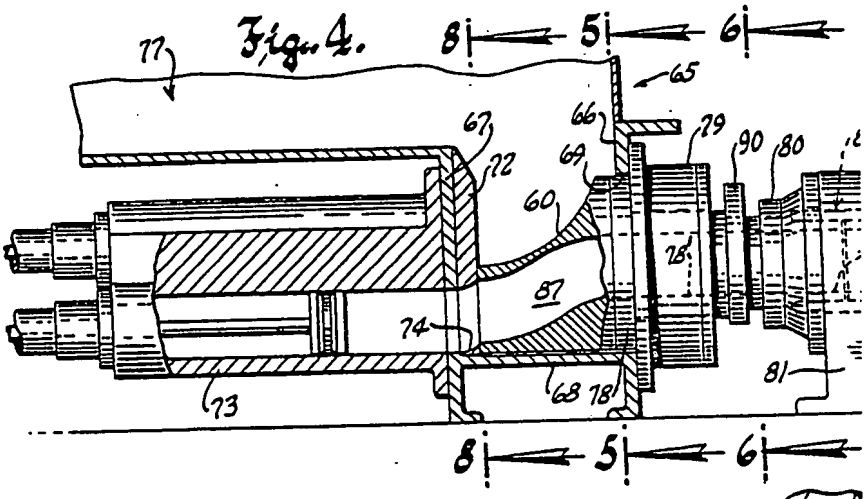
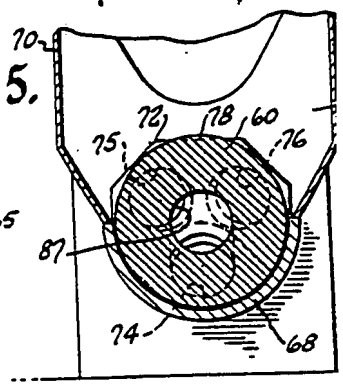


Fig. 5.



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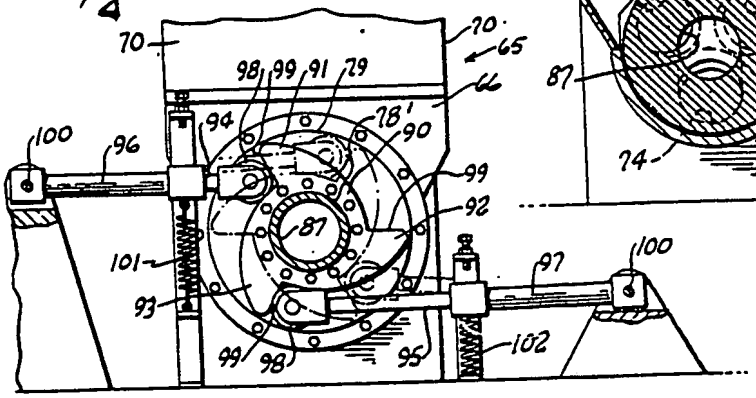


1063020 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

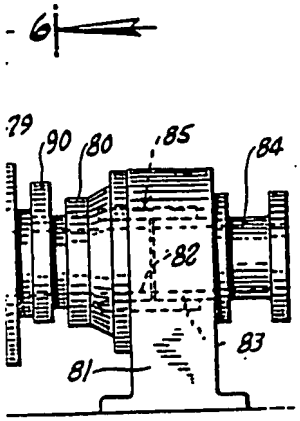
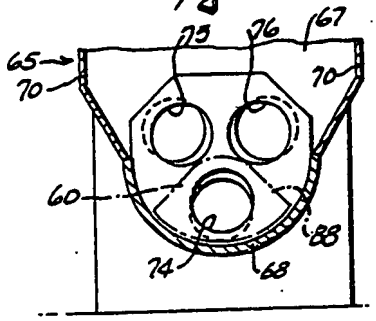
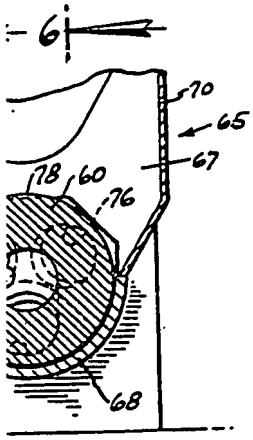


Fig. 8.





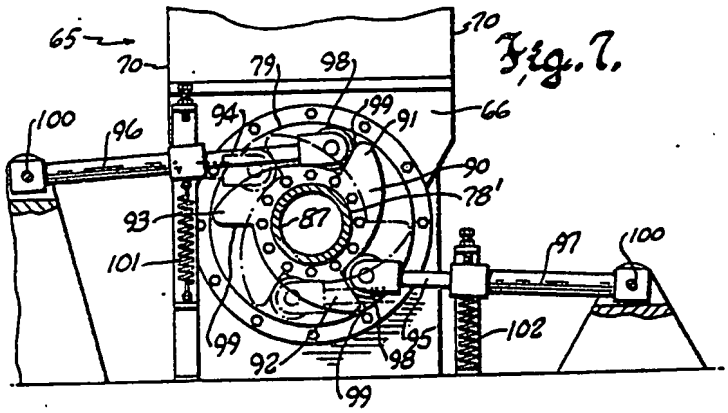
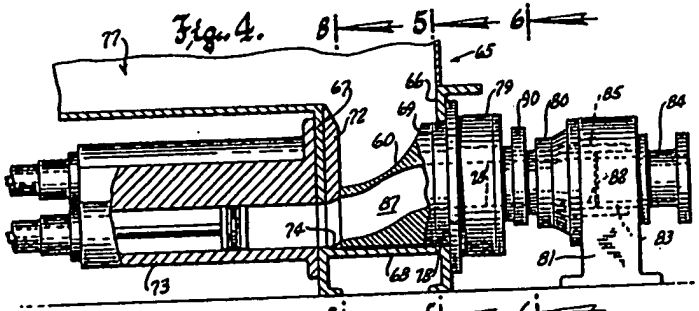


Fig. 7.

1063020 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

Fig. 4.



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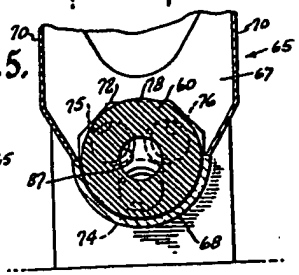

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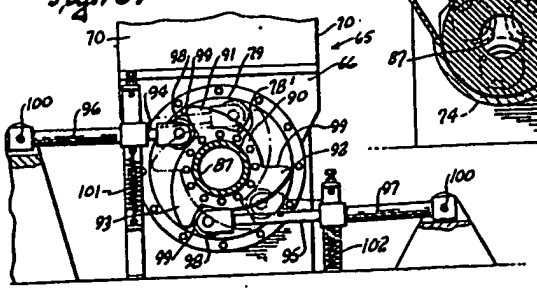

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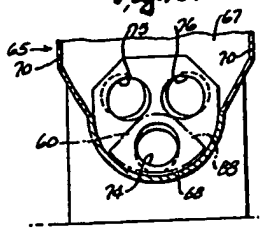

Fig. 7.